UCRL-ID-146615

Device Assembly Facility (DAF) Glovebox Radioactive Waste Characterization

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12/18/01

U.S. Department of Energy

Lawrence Livermore National Laboratory

DISCLAIMER

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

Introduction

The Device Assembly Facility (DAF) at the Nevada Test Site (NTS) provides programmatic support to the Joint Actinide Shock Physics Experimental Research (JASPER) Facility in the form of target assembly. The target assembly activities are performed in a glovebox at DAF and include Special Nuclear Material (SNM). Currently, only activities with transuranic SNM are anticipated. Preliminary discussions with facility personnel indicate that primarily two distributions of SNM will be used: Weapons Grade Plutonium (WG-Pu), and Pu-238 enhanced WG-Pu. Nominal radionuclide distributions for the two material types are included in attachment 1. Wastes generated inside glove boxes is expected to be Transuranic (TRU) Waste which will eventually be disposed of at the Waste Isolation Pilot Plant (WIPP). Wastes generated in the Radioactive Material Area (RMA), outside of the glove box is presumed to be low level waste (LLW) which is destined for disposal at the NTS. The process knowledge quantification methods identified herein may be applied to waste generated anywhere within or around the DAF and possibly JASPER as long as the fundamental waste stream boundaries are adhered to as outlined below. The method is suitable for quantification of waste which can be directly surveyed with the Blue Alpha meter or swiped. An additional quantification methodology which requires the use of a high resolution gamma spectroscopy unit is also included and relies on the predetermined radionuclide distribution and utilizes scaling to measured nuclides for quantification.

Operations overview

The portion of the facility where the radioactive material is handled in the glove box is maintained as a clean work environment, i.e. no loose contamination in areas outside of the glovebox or in the occupied areas. Several routine procedures are performed to ensure that the facility is maintained as a clean work area. Routine swipes are presently taken both monthly and quarterly throughout the RMA. Hands and shoes are monitored for contamination each time a person exits the RMA. When contamination is found by any of these methods, the source of the contamination is located and decontaminated or encapsulated. Hallways within the RMA are maintained as swipe free. Some potential sources for contamination in the RMA include breaches in glove boxes or other containers, HEPA changes, bag-in / bag-out operations, and glove changes.

The alpha survey instrument used in the DAF is a LLNL designed and manufactured instrument with an air proportional probe (Blue Alpha: LE-751854). The minimum detectable activity (MDA) for this instrument under ideal conditions is approximately 50 cpm with 50% efficiency =~100dpm. This portable instrument has a 100 cm^2 probe.

Use of administrative controls will be employed to segregate waste and conduct preliminary waste categorization. Waste generated within the glovebox and bagged out will be handled and packaged as TRU waste. Waste generated in the RMA outside of the glovebox will be packaged and handled as LLW. Waste generated outside of the glovebox is assumed to be non-contaminated. In the event of a spill or release, waste associated with the cleanup and any waste generated outside of the glovebox with measurable contamination on the blue alpha meter will be handled as TRU waste.

LLW activity will be quantified using the mass of the waste in the entire drum as if it all was contaminated at the MDA of the blue alpha.

TRU waste activity will be conservatively estimated using the mass of waste in each parcel and the highest contamination level measured on any surface in the parcel. The measurement of the high activity can be from direct survey or from a swipe survey with appropriate correction factors applied as outlined below.

Waste Characterization

Distribution development

When characterizing radioactive waste, knowledge of the radioactive isotopes contaminating the waste is required. Radioactive material and contamination is often a mixture of individual radioactive isotopes. The relative abundance of individual radioactive isotopes to the total activity or mass of the material or contamination is defined as the distribution. Input data for distribution development is often in the form of mass fractions however this must be converted to activity fractions for waste characterization. Distribution activity fractions are fractions of the total activity of the distribution regardless of decay mode. See attachment 1 for some nominal radionuclide distributions. These generic radionuclide distributions are used across LLNL Hazardous Waste Management (HWM) where applicable to characterize waste for disposal at the NTS and for WIPP. Additional project specific isotopic distributions may be developed using inventory controls, process knowledge, and historical analytical data if needed. As additional distributions are developed they will be documented on a case-by-case basis in later revisions of this document or project specific documentation such as Process Knowledge Evaluations (PKEs).

Radiological Characterization for transuranic nuclide contaminated waste coming from the DAF requires both an isotopic breakdown (distribution) and documented methods for quantification of the radionuclides in the waste.

Isotopic quantification will be done using information from the radiological control program in the facility. Specifically documented direct survey results with the blue alpha (gross radiation measurement), and/or documented swipe survey results (swipe to curie). Other methods may be employed as needed such as, gamma spectroscopy, laboratory analytical, or radionuclide scaling. Specific approaches to radiological identification and/or quantification other than methods documented here shall be documented and approved as they are developed and put into use. It should be noted that these quantification methods providing bounding radionuclide activities which the waste should not reasonably be expected to exceed. These bounding activities should be used for preliminary waste categorization, waste handling, and waste acceptance purposes. These methods are adequate to characterize LLW for disposal. However, TRU waste will require a WIPP certified analysis prior to disposal at WIPP. TRU waste should be packaged with consideration given to LLW certification requirements as some of this waste will undoubtedly be reclassified as LLW as a result of WIPP assay. Swipe and survey quantification techniques are only applicable to surface contaminated waste with measurable surfaces. Volumetrically contaminated waste should not be characterized using swipe and survey techniques.

Quantification

Four quantification methodologies for use at the DAF are described in detail below:

A. Gross radiation measurement using the blue alpha:

The following general equations demonstrate how TRU waste and LLW contaminated with alpha emitting radionuclides in a known distribution can be quantified using the blue alpha meter.

Meter efficiency correction is conducted as follows:

$$GA_x = \frac{GC_x}{Eff_x} \qquad \text{EqA1.}$$

Where: GA_x = Gross activity as measured with instrument x (dpm).
GC_x = Gross count rate as measured with instrument x (cpm).
Eff_x = Efficiency of instrument x (0.5 for the blue alpha).

Gross activity measured to waste activity material concentration calculations are conducted using the following algorithm:

$$GC_y = \frac{(GA_x)(K_{act})(S_y)}{(AD_y)(SA_x)} \qquad \text{EqA2.}$$

Where: GC_y = Gross activity concentration of waste material y (nCi/g).
GA_x = Gross activity as measured with instrument x (dpm).
K_{act} = Activity conversion factor (4.5E-04 nCi/dpm).
S_y = Number of sides of item y which are contaminated (i.e. 1 or 2)
AD_y = Areal Density of waste material y (g/cm^2).
SA_x = Surface area of probe on instrument x (cm^2).

Gross activity concentration to total parcel gross activity conversions are conducted using the weight of the parcel as outlined below:

$$TGA_z = (GC_y)(M_z) \qquad \text{Eq.A3.}$$

Where: TGA_z = Total gross activity of parcel z (nCi).
GC_y = Gross activity concentration of waste material y (nCi/g).
M_z = Mass of parcel z (g).

Conversion of total measured gross activity to total radioactivity and isotopic activity in the parcel requires knowledge of the isotopic composition (distribution) of the material being surveyed and the decay mode and probability of decay through the measured decay mode of each isotope. Suffice it to say that for known distributions of material, activity per decay mode can be calculated. A ratio of the decay mode specific activity and the total activity (regardless of decay mode) can be used to calculate total activity from measurements of a single type of radiation resulting from a single decay mode such as alpha decay. The ratio is calculated as follows:

$$K_{dec} = \frac{(SpA_{dm})}{(SpA_{tot})} \qquad \text{EqA4.}$$

Where: K_{dec} = Correction factor, gross measured activity to total activity.

SpA_{dm} = Decay mode specific, specific activity for the distribution.
SpA_{tot} = Total Specific activity for the distribution.

Conversion of gross total parcel activity to total parcel activity is conducted as follows:

$$TA = \frac{(TGA_z)}{(K_{dec})} \qquad \text{EqA5.}$$

Where: TA= Total Activity of parcel z (nCi).
TGA_z = Total gross activity of parcel z (nCi).
K_{dec} = Correction factor, gross measured activity to total activity.

Using the appropriate fractional abundance, the specific isotope activities can be calculated using the following algorithm:

$$A_i = (TA)(A_{frac}) \qquad \text{EqA6.}$$

Where: A_i = Activity of radionuclide, i, within the parcel.
TA= Total Activity of parcel z (nCi).
A_{frac} = Fractional abundance of radionuclide, i, within the distribution.

B. Gross radiation measurement using a Swipe

This technique is really a hybrid cross between smear to curie and gross radiation measurement using the blue alpha. For the DAF it is anticipated that the swipe will be used in place of the blue alpha meter. The swipe would then be counted on a gas flow proportional counter and only the gross alpha activity entered into the spreadsheet. The gas flow proportional counter results should already be corrected for efficiency of the counter giving results of gross alpha with units of dpm/swipe. Modification of Equation A2 allows us to use swipe data in place of direct survey data. Term GA_x is replaced by term GA_{sw}, term SA_x is replaced by term SA_{sw}, and a new term, E_{sw}, is added to allow correction for swipe efficiency. When using the swipe to assess gross contamination on waste, a conservative swipe efficiency must be included in the calculation. Gross activity

measured on the swipe to waste material activity concentration calculations are conducted using the following algorithm:

$$GC_y = \frac{(GA_{sw})(K_{act})(S_y)}{(AD_y)(SA_{sw})(E_{sw})} \qquad \text{EqB1.}$$

Where: GC_y = Gross activity concentration of waste material y (nCi/g).
GA_{sw} = Gross activity on the swipe (dpm).
K_{act} = Activity conversion factor (4.5E-04 nCi/dpm).
S_y = Number of sides of item y which are contaminated (i.e. 1 or 2)
AD_y = Areal Density of waste material y (g/cm^2).
SA_{sw} = Surface area swiped (cm^2).
E_{sw} = Swipe efficiency.

Parcel quantification is completed by application of equations A3 through A6 using term GC_y from EqB1.

Alternatively the swipe could be counted on a different instrument, such as a gamma spec, or subjected to destructive analytical methods for isotopic results. The method could then be modified to use scaling in conjunction with the isotopic results.

C. *Scaling using gamma spectroscopy.*

Proper application of scaling requires detailed knowledge of the radionuclide distribution. Scaling is the process of quantifying unmeasured radionuclides in a distribution by measurement of a single nuclide and application of scaling factors. Each unmeasured isotope in a distribution has a scaling factor to the single measured isotope. An individual scaling factor is calculated as the ratio of the unmeasured isotope fractional abundance to the measured isotopes fractional abundance. For the DAF it is anticipated that gamma spectroscopy will be conducted on whole parcels of waste. The gamma spec results will be corrected for efficiency, geometry, and matrix effects. The results shall be reported as the total parcel activity for a single isotope (as measured from one peak or several). The single isotope used for Pu mixtures is usually Am-241 or Pu-239 but could be any other easily measurable nuclide in the distribution. The parcels should be small and contain only low Z material and should be wrapped only in plastic. If the parcel is non-detect the corrected MDA can be used in the formula for the isotopic activity. The following algorithm is used to estimate the activity of each isotope in the parcel:

$$A_i = (A_{si})(SF_i) \qquad \text{EqC1.}$$

Where: A_i = Total activity of radionuclide, i, within the parcel.
A_{si} = Total activity of scaled isotope within the parcel.
SF_i = Scaling factor for radionuclide, i, relative to si

D. Gross radiation screening (PK Quantification) using the blue alpha MDA.

This is a modification to the gross radiation measurement technique, A, above. The blue alpha meter is used to screen waste and to quantify waste contaminated at or below the MDA of the blue alpha. Equations A1 through A6 are used with several small modifications. The modifications consist of using conservative assumptions to bound the potential activity in the waste. Some of the assumptions are outlined below:

1. S_y = 1, The waste material is contaminated on one side and the contamination is equally distributed.
2. SD_p = The waste has the same surface area per weight as 6 mil plastic. 6 mil plastic sheet has a areal density of 1.2E-02 g/cm^2.
3. MDA_b = The alpha meter used to measure the area is 50% efficient and the minimum detectable activity is 2.5 cpm/cm^2 =~5dpm/ cm^2.
4. All waste is contaminated at the MDA.

Assumption 1 is generally true in that only one side of most items will come in contact with the radioactive material.

Assumption 2 provides a method to convert surface area to weight. Six-mil plastic was chosen because it is one of the lighter items disposed of as waste and therefore provides a conservative estimate of the activity in the waste. Low areal density values are conservative because they equate to higher activity per a given weight.

Assumption 3 uses a MDA_b of 2.5 cpm/cm^2 =~5dpm/ cm^2 which is 5 times the actual MDA_b of 0.5 cpm/cm^2 =~1dpm/ cm^2 for the LLNL Blue Alpha Meter. A MDA_b of 0.5 cpm/cm^2 =~1dpm/cm^2 is for the ideal flat and smooth surface and the MDA_b of 2.5 cpm/cm^2 =~5dpm/cm^2 is to provide for surfaces that are not ideal.

Assumption 4 provides an estimate of the quantity of activity in the waste. By using the MDA for all material this will help ensure that the quantity of alpha emitters in the waste is not under estimated.

By converting surface area contaminated at MDA weight it is determined that the waste will contain approximately 0.20 nCi per gram. Equation A2 is modified to include the assumptions. Term GA_x is replaced by term MDA_b which is the MDA of the blue alpha meter. Term SA_x is dropped as the MDA is expressed in terms of dpm / cm^2. Term Sy is dropped because we have assumed only one side of the waste is contaminated (really none are). The following calculation demonstrates the quantification:

$$GC_y = \frac{(MDA_b)(K_{act})}{(AD_y)} = 0.19 \approx 0.20 nCi / g \qquad \text{EqD1.}$$

Where: GC_y = Gross activity concentration of waste material y (nCi/g).
MDA_b = Conservative MDA for the blue alpha (5dpm/ cm^2).
K_{act} = Activity conversion factor (4.5E-04 nCi/dpm).
AD_y = Areal Density of waste material y (1.2E-02 g/cm^2).

Waste quantification can now be completed through application of equations A3 through A6.

Areal Density

The following table provides a sampling of common waste materials and their respective areal densities:

Item	Areal Density (g/cm^2)
Six-mil Plastic Sheet	1.2E-02
20# Copier Paper	1.0E-02
Powderless Gloves	2.0E-02
Heavy Rubber Gloves	4.8E-02
Plastic and Launderable Shoe Covers	1.2E-01
Coverall Material	1.9E-02 - 2.8E-02
Twelve-mil Plastic	2.4E-02

Application of quantification methodologies to DAF waste.

LLW will be quantified using method D or C on a case-by-case basis. All waste from within the glovebox and contaminated waste generated outside of the glovebox will be handled as TRU waste. Waste from inside the glovebox is considered guilty by association and waste from outside the glovebox contaminated above MDA of the blue alpha is to be handled as TRU for conservatism.

Waste with measurable activity will be handled and packaged as TRU waste pending WIPP certified analysis. If waste re-classification is necessary it can be conducted after the WIPP certified analysis is conducted. Any WIPP certified analysis will also be adequate to quantify radioactivity for certification as LLW.

TRU waste must always be documented and tracked at the parcel level but LLW may be documented at the drum level when characterized by method D.

When quantifying TRU waste the highest gross alpha activity measured on the item must be entered into the quantification spreadsheet to quantify the isotopic activity in each parcel of TRU waste.

Attachments 2 through 5 are samples of the quantification spreadsheets to be used for waste quantification. The spreadsheet to use is dependent on the quantification methodology being employed. The waste stream summary sheets will provide additional guidance on waste handling and packaging.

Justification for using MDA for activity calculations of LLW:

Waste will undergo direct survey with the blue alpha meter. Waste with measurable contamination will be segregated from waste that is at or below the MDA of the blue alpha meter. Segregation of contaminated waste from <MDA waste will be conducted when waste is being packaged. Waste with measurable contamination will be quantified based upon actual instrument readings, swipe to curie conversions, or other documented methods as appropriate. The MDA characterization method is only for material with no measurable contamination.

Conclusions:

By using these radiological quantification methods as described to determine the quantity of alpha emitters in a waste container it can be ensured that waste items contaminated with TRU levels of alpha emitters will not end up in the low level waste stream. Additionally TRU waste can be adequately and conservatively characterized to allow for proper storage pending WIPP certified analysis.

Attachments:

1. Nominal Pu distributions.
2. DAF blue alpha meter MDA spreadsheet.
3. DAF Total alpha activity to isotopic activity spreadsheet.
4. DAF worksheet for scaling to Pu-239.
5. DAF worksheet for scaling to Am-241.
6. DAF swipe to isotopic activity spreadsheet.
7. DAF blue alpha survey to isotopic activity spreadsheet.

Nominal Pu Distributions

Type of Pu	Isotope	Weight (%)	Weight Fraction	SpA (Ci/g)	Mixture SpA (Ci/g)	Activity Fraction	Activity % (%)
Weapons Grade	Pu-238	1.60E-02	1.60E-04	1.73E+01	2.77E-03	5.79E-03	5.79E-01
	Pu-239	9.35E+01	9.35E-01	6.30E-02	5.89E-02	1.23E-01	1.23E+01
	Pu-240	5.90E+00	5.90E-02	2.30E-01	1.36E-02	2.84E-02	2.84E+00
	Pu-241	3.81E-01	3.81E-03	1.04E+02	3.96E-01	8.28E-01	8.28E+01
	Pu-242	4.00E-02	4.00E-04	4.00E-03	1.60E-06	3.34E-06	3.34E-04
	Am-241	2.01E-01	2.01E-03	3.47E+00	6.97E-03	1.46E-02	1.46E+00
		1.00E+02	1.00E+00		4.78E-01	1.00E+00	1.00E+02
Fuel Grade	Pu-238	6.70E-02	6.70E-04	1.73E+01	1.16E-02	8.30E-03	8.30E-01
	Pu-239	7.90E+01	7.90E-01	6.30E-02	4.97E-02	3.56E-02	3.56E+00
	Pu-240	1.74E+01	1.74E-01	2.30E-01	4.01E-02	2.87E-02	2.87E+00
	Pu-241	1.18E+00	1.18E-02	1.04E+02	1.23E+00	8.79E-01	8.79E+01
	Pu-242	4.30E-01	4.30E-03	4.00E-03	1.72E-05	1.23E-05	1.23E-03
	Am-241	1.94E+00	1.94E-02	3.47E+00	6.73E-02	4.82E-02	4.82E+00
		1.00E+02	1.00E+00		1.40E+00	1.00E+00	1.00E+02
Reactor Grade	Pu-238	1.10E-02	1.10E-04	1.73E+01	1.90E-03	3.28E-03	3.28E-01
	Pu-239	7.37E+01	7.37E-01	6.30E-02	4.64E-02	7.99E-02	7.99E+00
	Pu-240	2.49E+01	2.49E-01	2.30E-01	5.73E-02	9.86E-02	9.86E+00
	Pu-241	4.24E-01	4.24E-03	1.04E+02	4.41E-01	7.59E-01	7.59E+01
	Pu-242	1.80E-02	1.80E-04	4.00E-03	7.20E-07	1.24E-06	1.24E-04
	Am-241	9.94E-01	9.94E-03	3.47E+00	3.45E-02	5.94E-02	5.94E+00
		1.00E+02	1.00E+00		5.81E-01	1.00E+00	1.00E+02
Americium Enriched	Pu-238	5.50E-02	5.50E-04	1.73E+01	9.52E-03	5.28E-03	5.28E-01
	Pu-239	6.36E+01	6.36E-01	6.30E-02	4.00E-02	2.22E-02	2.22E+00
	Pu-240	1.40E+01	1.40E-01	2.30E-01	3.23E-02	1.79E-02	1.79E+00
	Pu-241	9.50E-01	9.50E-03	1.04E+02	9.88E-01	5.49E-01	5.49E+01
	Pu-242	3.46E-01	3.46E-03	4.00E-03	1.38E-05	7.68E-06	7.68E-04
	Am-241	2.11E+01	2.11E-01	3.47E+00	7.31E-01	4.06E-01	4.06E+01
		1.00E+02	1.00E+00		1.80E+00	1.00E+00	1.00E+02
Mixed Pu	Pu-238	4.20E-02	4.20E-04	1.73E+01	7.27E-03	7.72E-03	7.72E-01
	Pu-239	8.61E+01	8.61E-01	6.30E-02	5.43E-02	5.77E-02	5.77E+00
	Pu-240	1.17E+01	1.17E-01	2.30E-01	2.69E-02	2.86E-02	2.86E+00
	Pu-241	7.84E-01	7.84E-03	1.04E+02	8.15E-01	8.66E-01	8.66E+01
	Pu-242	2.36E-01	2.36E-03	4.00E-03	9.44E-06	1.00E-05	1.00E-03
	Am-241	1.08E+00	1.08E-02	3.47E+00	3.74E-02	3.98E-02	3.98E+00
		1.00E+02	1.00E+00		9.41E-01	1.00E+00	1.00E+02
Pu-238 enhanced	Pu-238	8.02E+00	8.02E-02	1.73E+01	1.39E+00	7.47E-01	7.47E+01
	Pu-239	8.55E+01	8.55E-01	6.30E-02	5.38E-02	2.90E-02	2.90E+00
	Pu-240	5.90E+00	5.90E-02	2.30E-01	1.36E-02	7.31E-03	7.31E-01
	Pu-241	3.81E-01	3.81E-03	1.04E+02	3.96E-01	2.13E-01	2.13E+01
	Pu-242	4.00E-02	4.00E-04	4.00E-03	1.60E-06	8.61E-07	8.61E-05
	Am-241	2.02E-01	2.02E-03	3.47E+00	7.01E-03	3.77E-03	3.77E-01
		1.00E+02			1.86E+00	1.00E+00	1.00E+02

DAF MDA on the Blue Alpha, 100% survey, non-volumetric contamination Activity assignment based on weight Spreadsheet.

Requisition Number:	W200419			
Container ID Number:	Q000055399			
Package Gross Weight:	78.55	lbs	453.5924	g/lb
Package Gross Weight:	3.5811E+04	grams		
PK conc. @ MDA	0.2	nCi/g of waste		
Package Total Activity	7.1622E+03	nCi		

Type of Pu	Isotope	Wt. %	Wt. Fraction	SpA (Ci/g)	Mixture SpA (Ci/g)	WGPu Activity Fraction	Normalized Activity fraction w/o Pu-241	Package Activity Nano-Ci
Weapons Grade	Pu-238	1.60E-02	1.60E-04	1.73E+01	2.77E-03	5.79E-03	3.37E-02	2.41E+02
	Pu-239	9.35E+01	9.35E-01	6.30E-02	5.89E-02	1.23E-01	7.16E-01	5.13E+03
	Pu-240	5.90E+00	5.90E-02	2.30E-01	1.36E-02	2.84E-02	1.65E-01	1.18E+03
	Pu-241	3.81E-01	3.81E-03	1.04E+02	3.96E-01	8.28E-01		34511.9043
	Pu-242	4.00E-02	4.00E-04	4.00E-03	1.60E-06	3.34E-06	1.95E-05	1.39E-01
	Am-241	2.02E-01	2.02E-03	3.47E+00	7.01E-03	1.46E-02	8.52E-02	6.11E+02
				Total	4.78E-01	1.00E+00	1.00E+00	4.17E+04
					w/o Pu-241	1.72E-01	w/o Pu-241	7.16E+03

Type of Pu	Isotope	Wt. %	Wt. Fraction	SpA (Ci/g)	Mixture SpA (Ci/g)	WGPu Activity Fraction	Normalized Activity fraction w/o Pu-241	Package Activity Nano-Ci
Pu-238 Enhanced	Pu-238	8.02E+00	8.02E-02	1.73E+01	1.39E+00	7.47E-01	9.49E-01	6.80E+03
	Pu-239	8.55E+01	8.55E-01	6.30E-02	5.38E-02	2.90E-02	3.68E-02	2.64E+02
	Pu-240	5.90E+00	5.90E-02	2.30E-01	1.36E-02	7.31E-03	9.29E-03	6.65E+01
	Pu-241	3.81E-01	3.81E-03	1.04E+02	3.96E-01	2.13E-01		1942.22555
	Pu-242	4.00E-02	4.00E-04	4.00E-03	1.60E-06	8.61E-07	1.09E-06	7.84E-03
	Am-241	2.02E-01	2.02E-03	3.47E+00	7.01E-03	3.77E-03	4.80E-03	3.44E+01
		1.00E+02		Total	1.86E+00	1.00E+00	1.00E+00	9.10E+03
					w/o Pu-241	7.87E-01	w/o Pu-241	7.16E+03

Assumptions:

1. All activities are at <MDA on the Blue Alpha survey meter.
2. Isotopic distribution of material is weapons grade Pu OR Pu-238 Enhanced.
3. Activity concentration is conservatively calculated based upon activity per unit mass as identified in the approved PK method.
4. See approved PK characterization process.
5. Weight must be measured on a calibrated scale.

Entered by:
Date:

DAF Memo (TOTAL ACTIVITY PER PARCEL) Gross Alpha Activity to Isotopic Activity.

Requisition Number: Wxxx
Container ID Number: Q000xxxx

Item TOTAL Gross Alpha Activity 1.0000E+00 Nano-Ci

Type of Pu	Isotope	Wt. %	Wt. Fraction	SpA (Ci/g)	Mixture SpA (Ci/g)	WGPu Activity Fraction	Normalized Activity fraction w/o Pu-241	Package Activity Nano-Ci
Weapons Grade	Pu-238	1.60E-02	1.60E-04	1.73E+01	2.77E-03	5.79E-03	3.37E-02	3.37E-02
	Pu-239	9.35E+01	9.35E-01	6.30E-02	5.89E-02	1.23E-01	7.16E-01	7.16E-01
	Pu-240	5.90E+00	5.90E-02	2.30E-01	1.36E-02	2.84E-02	1.65E-01	1.65E-01
	Pu-241	3.81E-01	3.81E-03	1.04E+02	3.96E-01	8.28E-01		4.82E+00
	Pu-242	4.00E-02	4.00E-04	4.00E-03	1.60E-06	3.34E-06	1.95E-05	1.95E-05
	Am-241	2.02E-01	2.02E-03	3.47E+00	7.01E-03	1.46E-02	8.52E-02	8.52E-02
				Total	4.78E-01	1.00E+00	1.00E+00	5.82E+00
					w/o Pu-241	1.72E-01	w/o Pu-241	1.00E+00

Type of Pu	Isotope	Wt. %	Wt. Fraction	SpA (Ci/g)	Mixture SpA (Ci/g)	WGPu Activity Fraction	Normalized Activity fraction w/o Pu-241	Package Activity Nano-Ci
Pu-238 Enhanced	Pu-238	8.02E+00	8.02E-02	1.73E+01	1.39E+00	7.47E-01	9.49E-01	9.49E-01
	Pu-239	8.55E+01	8.55E-01	6.30E-02	5.38E-02	2.90E-02	3.68E-02	3.68E-02
	Pu-240	5.90E+00	5.90E-02	2.30E-01	1.36E-02	7.31E-03	9.29E-03	9.29E-03
	Pu-241	3.81E-01	3.81E-03	1.04E+02	3.96E-01	2.13E-01		2.71E-01
	Pu-242	4.00E-02	4.00E-04	4.00E-03	1.60E-06	8.61E-07	1.09E-06	1.09E-06
	Am-241	2.02E-01	2.02E-03	3.47E+00	7.01E-03	3.77E-03	4.80E-03	4.80E-03
		1.00E+02		Total	1.86E+00	1.00E+00	1.00E+00	1.27E+00
					w/o Pu-241	7.87E-01	w/o Pu-241	1.00E+00

1. All activities are in NanoCuries from a documented survey or HP memo.
2. Isotopic distribution of material is weapons grade Pu OR Pu-238 Enhanced.
3. Activity in the memo is total ALPHA activity.

Entered by: J.Bolinick
Date: 8/22/2001

DAF Scaling Pu-239 Total activity to Isotopic activity.

Item Identification (Q#)	
Item Identification (W#)	
CES COC Number/Sample ID	
Total parcel Activity of Pu-239 reported by Gamma Spec (nCi)	1000 Use MDA if activity is not identified.
Total mass of the parcel (grams)	1

Type of Pu	Isotope	Wt. %	Wt. Fraction	SpA (Ci/g)	Ci/g Mixture	Activity Fraction	Activity %		Parcel Activity (nCi)	Parcel Concentration TRU (nCi/g)	GTCC TRU nCi/g	Pu-241 nCi/g	Sum of Fractions	Parcel Pu-241 nCi/g	Parcel Sum of Fractions
Weapons Grade	Pu-238	0.016	0.00016	17.3	0.002768	0.005785	0.57851		47.009						
	Pu-239	93.464	0.93464	0.063	0.0588823	0.123063	12.3063		1000						
	Pu-240	5.9	0.059	0.23	0.01357	0.028361	2.83612		230.46						
	Pu-241	0.381	0.00381	104	0.39624	0.828137	82.8137		6729.35	1396.536685	85	494.581167	0.991309	6729.35441	15.888
	Pu-242	0.04	0.0004	0.004	0.0000016	3.34E-06	0.00033		0.02717						
	Am-241	0.202	0.00202	3.47	0.0070094	0.01465	1.46496		119.041						
		100.003	1.00003		0.4784713	1	100	Total	8125.89						
								TRU total	1396.54						
Fuel Grade	Pu-238	0.066	0.00066	17.3	0.011418	0.008182	0.8182		229.52						
	Pu-239	78.964	0.78964	0.063	0.0497473	0.035648	3.56483		1000						
	Pu-240	17.427	0.17427	0.23	0.0400821	0.028722	2.87223		805.714						
	Pu-241	1.18	0.0118	104	1.2272	0.879395	87.9395		24668.7	3383.199336	80	663.321599	0.98952	24668.6656	40.8802
	Pu-242	0.432	0.00432	0.004	1.728E-05	1.24E-05	0.00124		0.34736						
	Am-241	1.932	0.01932	3.47	0.0670404	0.04804	4.80402		1347.62						
		100.001	1.00001		1.3955051	1	100	Total	28051.9						
								TRU total	3383.2						
Pu-238 enhanced	Pu-238	8.016	0.08016	17.3	1.386768	0.746605	74.6605		25756.1						
(~8 wt. %)	Pu-239	85.464	0.85464	0.063	0.0538423	0.028988	2.89875		1000						
	Pu-240	5.9	0.059	0.23	0.01357	0.007306	0.73058		252.032						
	Pu-241	0.381	0.00381	104	0.39624	0.213327	21.3327		7359.27	27138.34248	96	122.032895	0.994867	7359.26684	273.486
	Pu-242	0.04	0.0004	0.004	0.0000016	8.61E-07	8.6E-05		0.02972						
	Am-241	0.202	0.00202	3.47	0.0070094	0.003774	0.37737		130.184						
		100.003			1.8574313	1	100	Total	34497.6						
								TRU total	27138.3						

	nCi/g
TRU Limit (20yr)	100
GTCC TRU Limit (5yr)	100
GTCC Pu-241Limit	3500

DAF Scaling Total Am-241 Activity to Isotopic activity.

Item identification (W#)	Wxxxx
Item identification (Q#)	Qxxxxx
CES COC Number/Sample ID	COC#
Total item Activity of Am-241 reported by Gamma Spec (nCi)	1000 Use MDA if activity is not identified.
Total mass of the item (grams)	2267

Type of Pu	Isotope	Wt. %	Wt. Fraction	SpA (Ci/g)	Ci/g Mixture	Activity Fraction	Activity %		Parcel Activity (nCi)	Parcel Concentration TRU (nCi/g)	GTCC TRU nCi/g	Pu-241 nCi/g	Sum of Fractions	Parcel Pu-241 nCi/g	Parcel Sum of Fractions
Weapons Grade	Pu-238	0.016	0.00016	17.3	0.002768	0.005785	0.57851		394.898						
	Pu-239	93.464	0.93464	0.063	0.0588823	0.123063	12.3063		8400.48						
	Pu-240	5.9	0.059	0.23	0.01357	0.028361	2.83612		1935.97						
	Pu-241	0.381	0.00381	104	0.39624	0.828137	82.8137		56529.8	5.174934978	85	494.581167	0.99131	24.9359518	0.05887
	Pu-242	0.04	0.0004	0.004	0.0000016	3.34E-06	0.00033		0.22826						
	Am-241	0.202	0.00202	3.47	0.0070094	0.01465	1.46496		1000						
		100.003	1.00003		0.4784713	1	100	Total	68261.4						
								TRU total	11731.6						
Fuel Grade	Pu-238	0.066	0.00066	17.3	0.011418	0.008182	0.8182		170.315						
	Pu-239	78.964	0.78964	0.063	0.0497473	0.035648	3.56483		742.05						
	Pu-240	17.427	0.17427	0.23	0.0400821	0.028722	2.87223		597.88						
	Pu-241	1.18	0.0118	104	1.2272	0.879395	87.9395		18305.4	1.107411832	80	663.321599	0.98952	8.0747155	0.01338
	Pu-242	0.432	0.00432	0.004	1.728E-05	1.24E-05	0.00124		0.25776						
	Am-241	1.932	0.01932	3.47	0.0670404	0.04804	4.80402		1000						
		100.001	1.00001		1.3955051	1	100	Total	20815.9						
								TRU total	2510.5						
Pu-238 enhanced (~8 wt. %)	Pu-238	8.016	0.08016	17.3	1.386768	0.746605	74.6605		197844						
	Pu-239	85.464	0.85464	0.063	0.0538423	0.028988	2.89875		7681.44						
	Pu-240	5.9	0.059	0.23	0.01357	0.007306	0.73058		1935.97						
	Pu-241	0.381	0.00381	104	0.39624	0.213327	21.3327		56529.8	91.95486673	96	122.032895	0.99487	24.9359518	0.92667
	Pu-242	0.04	0.0004	0.004	0.0000016	8.61E-07	8.6E-05		0.22826						
	Am-241	0.202	0.00202	3.47	0.0070094	0.003774	0.37737		1000						
		100.003			1.8574313	1	100	Total	264991						
								TRU total	208462						

	nCi/g
TRU Limit (20yr)	100
GTCC TRU Limit (5yr)	100
GTCC Pu-241Limit	3500

DAF Swipe to Isotopic Activity Spreadsheet

Parcel Card Number: [redacted]
Container ID Number: [redacted]
High Swipe Result (**dpm**) [redacted] dpm/10cm^2

Alpha nCi/g of waste. 100.05 Nano-Ci / g
Measured parcel weight in grams. [redacted] g

Parcel TOTAL Gross Alpha Activity. 1.0005E+05 Nano-Ci

Type of Pu	Isotope	Wt. %	Wt. Fraction	SpA (Ci/g)	Mixture SpA (Ci/g)	WGPu Activity Fraction	Normalized Activity fraction w/o Pu-241	Package Activity Nano-Ci
Weapons Grade	Pu-238	1.60E-02	1.60E-04	1.73E+01	2.77E-03	5.79E-03	3.37E-02	3.37E+03
	Pu-239	9.35E+01	9.35E-01	6.30E-02	5.89E-02	1.23E-01	7.16E-01	7.16E+04
	Pu-240	5.90E+00	5.90E-02	2.30E-01	1.36E-02	2.84E-02	1.65E-01	1.65E+04
	Pu-241	3.81E-01	3.81E-03	1.04E+02	3.96E-01	8.28E-01		4.82E+05
	Pu-242	4.00E-02	4.00E-04	4.00E-03	1.60E-06	3.34E-06	1.95E-05	1.95E+00
	Am-241	2.02E-01	2.02E-03	3.47E+00	7.01E-03	1.46E-02	8.52E-02	8.53E+03
				Total	4.78E-01	1.00E+00	1.00E+00	5.82E+05
					w/o Pu-241	1.72E-01	w/o Pu-241	1.00E+05

Type of Pu	Isotope	Wt. %	Wt. Fraction	SpA (Ci/g)	Mixture SpA (Ci/g)	WGPu Activity Fraction	Normalized Activity fraction w/o Pu-241	Package Activity Nano-Ci
Pu-238 Enhanced	Pu-238	8.02E+00	8.02E-02	1.73E+01	1.39E+00	7.47E-01	9.49E-01	9.50E+04
	Pu-239	8.55E+01	8.55E-01	6.30E-02	5.38E-02	2.90E-02	3.68E-02	3.69E+03
	Pu-240	5.90E+00	5.90E-02	2.30E-01	1.36E-02	7.31E-03	9.29E-03	9.29E+02
	Pu-241	3.81E-01	3.81E-03	1.04E+02	3.96E-01	2.13E-01		2.71E+04
	Pu-242	4.00E-02	4.00E-04	4.00E-03	1.60E-06	8.61E-07	1.09E-06	1.10E-01
	Am-241	2.02E-01	2.02E-03	3.47E+00	7.01E-03	3.77E-03	4.80E-03	4.80E+02
		1.00E+02		Total	1.86E+00	1.00E+00	1.00E+00	1.27E+05
					w/o Pu-241	7.87E-01	w/o Pu-241	1.00E+05

1. Assume both sides of the waste are contaminated
2. Assume all waste is contaminated at the highest level measured on the swipe.
3. A conservative areal density for 6 mil plastic is applied to all the waste (1.2E-02 g/cm^2).
4. Assume swipe has a swipe area of 10 cm^2.
5. Assume swipe efficiency is 5%.
6. Swipe values are to be efficiency corrected alpha activity per swipe only.

Entered by: [redacted]
Date: [redacted]

Blue Alpha to Isotopic Activity sheet.

Parcel Card Number:	[redacted]	
Container ID Number:	[redacted]	
High Blue Alpha reading	[redacted]607	cpm/100cm^2
Conversion to dpm.	1334	dpm/100cm^2
Alpha nCi/g of waste.	1.0005	Nano-Ci / g
Measured parcel weight in grams.	[redacted]1000	g

Parcel TOTAL Gross Alpha Activity 1.0005E+03 Nano-Ci

Type of Pu	Isotope	Wt. %	Wt. Fraction	SpA (Ci/g)	Mixture SpA (Ci/g)	WGPu Activity Fraction	Normalized Activity fraction w/o Pu-241	Package Activity Nano-Ci
Weapons Grade	Pu-238	1.60E-02	1.60E-04	1.73E+01	2.77E-03	5.79E-03	3.37E-02	3.37E+01
	Pu-239	9.35E+01	9.35E-01	6.30E-02	5.89E-02	1.23E-01	7.16E-01	7.16E+02
	Pu-240	5.90E+00	5.90E-02	2.30E-01	1.36E-02	2.84E-02	1.65E-01	1.65E+02
	Pu-241	3.81E-01	3.81E-03	1.04E+02	3.96E-01	8.28E-01		4.82E+03
	Pu-242	4.00E-02	4.00E-04	4.00E-03	1.60E-06	3.34E-06	1.95E-05	1.95E-02
	Am-241	2.02E-01	2.02E-03	3.47E+00	7.01E-03	1.46E-02	8.52E-02	8.53E+01
				Total	4.78E-01	1.00E+00	1.00E+00	5.82E+03
					w/o Pu-241	1.72E-01	w/o Pu-241	1.00E+03

Type of Pu	Isotope	Wt. %	Wt. Fraction	SpA (Ci/g)	Mixture SpA (Ci/g)	WGPu Activity Fraction	Normalized Activity fraction w/o Pu-241	Package Activity Nano-Ci
Pu-238 Enhanced	Pu-238	8.02E+00	8.02E-02	1.73E+01	1.39E+00	7.47E-01	9.49E-01	9.50E+02
	Pu-239	8.55E+01	8.55E-01	6.30E-02	5.38E-02	2.90E-02	3.68E-02	3.69E+01
	Pu-240	5.90E+00	5.90E-02	2.30E-01	1.36E-02	7.31E-03	9.29E-03	9.29E+00
	Pu-241	3.81E-01	3.81E-03	1.04E+02	3.96E-01	2.13E-01		2.71E+02
	Pu-242	4.00E-02	4.00E-04	4.00E-03	1.60E-06	8.61E-07	1.09E-06	1.10E-03
	Am-241	2.02E-01	2.02E-03	3.47E+00	7.01E-03	3.77E-03	4.80E-03	4.80E+00
		1.00E+02		Total	1.86E+00	1.00E+00	1.00E+00	1.27E+03
					w/o Pu-241	7.87E-01	w/o Pu-241	1.00E+03

1. Assume both sides of the waste are contaminated
2. Assume all waste is contaminated at the highest level measured on the blue alpha.
3. A conservative areal density for 6 mil plastic is applied to all the waste (1.2E-02 g/cm^2).

Entered by: [redacted]
Date: [redacted]